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Fourier Transform Infrared Spectroscopy Analysis of Human Osteosarcoma Bone Tissue

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Abstract

Since the middle of the XXth century, Fourier transform infrared (FT-IR) spectroscopy has been employed as a nondestructive, label-free, highly sensitive, and specific analytical method with many potential applications in different fields of biomedical research and in particular cancer research and diagnosis. In this study, infrared spectra of normal human bone and tumor tissue of osteosarcoma were analyzed using FT-IR spectroscopy in the range of 800–1800 cm^{-1}. The results revealed that some of the spectral characteristics varied significantly between normal and malignant tissues, that is, IR peak positions, and the spectral intensities. The main changes in the spectral features of tissues were observed in the phosphate $\nu 1$, $\nu 3$ contour (950–1200 cm^{-1}) and Amide I (1620–1680 cm^{-1}) and II (1520–1570 cm^{-1}) bands. The molecular interpretation of the differences between normal and pathological states of bone tissues may indicate the changes in hydroxyapatite mineralization and collagen structure of the malignant tissue. The most important application of this technique is evaluation of the disease states and the results of therapeutic intervention under the medical treatment.

Keywords FT-IR-spectroscopy · Bone · Osteosarcoma · Hydroxyapatite · Collagen

1 Introduction

Cancer is biostructure disorders including uncontrolled cell division, invasive cell growth into adjacent tissue, and metastatic implantation to other body sites [1]. It is becoming the leading cause of death around the world. Further developments in cancer treatment as well as diagnostic methods are required. One of the available techniques that can effectively provide information concerning the structure and chemical composition of biological materials in various human cancers at the molecular level in a nondestructive and label-free manner is Fourier transform infrared spectroscopy (FT-IR) [2]. The great advantage of FT-IR spectroscopy is that any sample (a variety of human body fluids, tissues, and calcified minerals) may be studied in virtually any state and no specific reagents are required. The FT-IR wavenumber range from 4000 to 400 cm^{-1} includes the so-called biofingerprint region (1800 to 900 cm^{-1}), containing the fundamental vibrational modes of key chemical bonds that may provide a nondestructive, screening approach for the detection, identification, and characterization of the molecular components of biological processes in tissues [3]. Since molecular structure and function are strongly correlated, changes of structure may be used to elucidate a pathological status of tissue [2].

In the past three decades, FT-IR spectroscopic analysis has become an essential tool for the detection, identification, and characterization of the molecular components of biological processes that is responsible for the dynamic properties of cancer progression [4]. FT-IR spectroscopy has been successfully applied to study the different types of cancer including breast, prostate, lung, cervical, colon, brain, skin, and liver tumors [5–8]. Osteosarcoma is a malignant tumor characterized by spindle cells of mesenchymal origin depositing immature osteoid matrix that primarily affects the long bones but can also involve other bones in the body [9]. FT-IR spectroscopy has been used since the 1960s to characterize the mineral and

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